Comparative Evaluation of Groundwater Data
Caltrans Modesto Soil Stockpiles
Stanislaus County, California

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Executive Summary

This report has been prepared on behalf of the California Department of Transportation (Caltrans) to develop and implement a comparative evaluation of groundwater data from the Caltrans Modesto Soil Stockpiles and FMC's Modesto plant. The comparative analysis is based primarily on various statistical parameters, such as background values calculated using the 95-percent upper confidence limit, mean concentrations, and trend analysis.

FMC and its predecessors operated a chemical processing facility in Modesto, California from 1929 to approximately 1985. The facility processed barium and strontium minerals (barite and celestite) and other materials to produce a variety of industrial chemicals. From the early 1950s to the late 1970s, liquid wastes were discharged to seven unlined ponds. Eight constituents of concern have been identified in groundwater due to FMC's operations:

- elevated pH levels;
- nitrate;
- sulfate;
- sulfide;
- total dissolved solids (TDS);
- arsenic;
- barium; and
- strontium.

RWQCB has issued several orders requiring investigation and cleanup of the FMC site. Almost 1 billion gallons of groundwater have been extracted and treated by FMC since 1996.

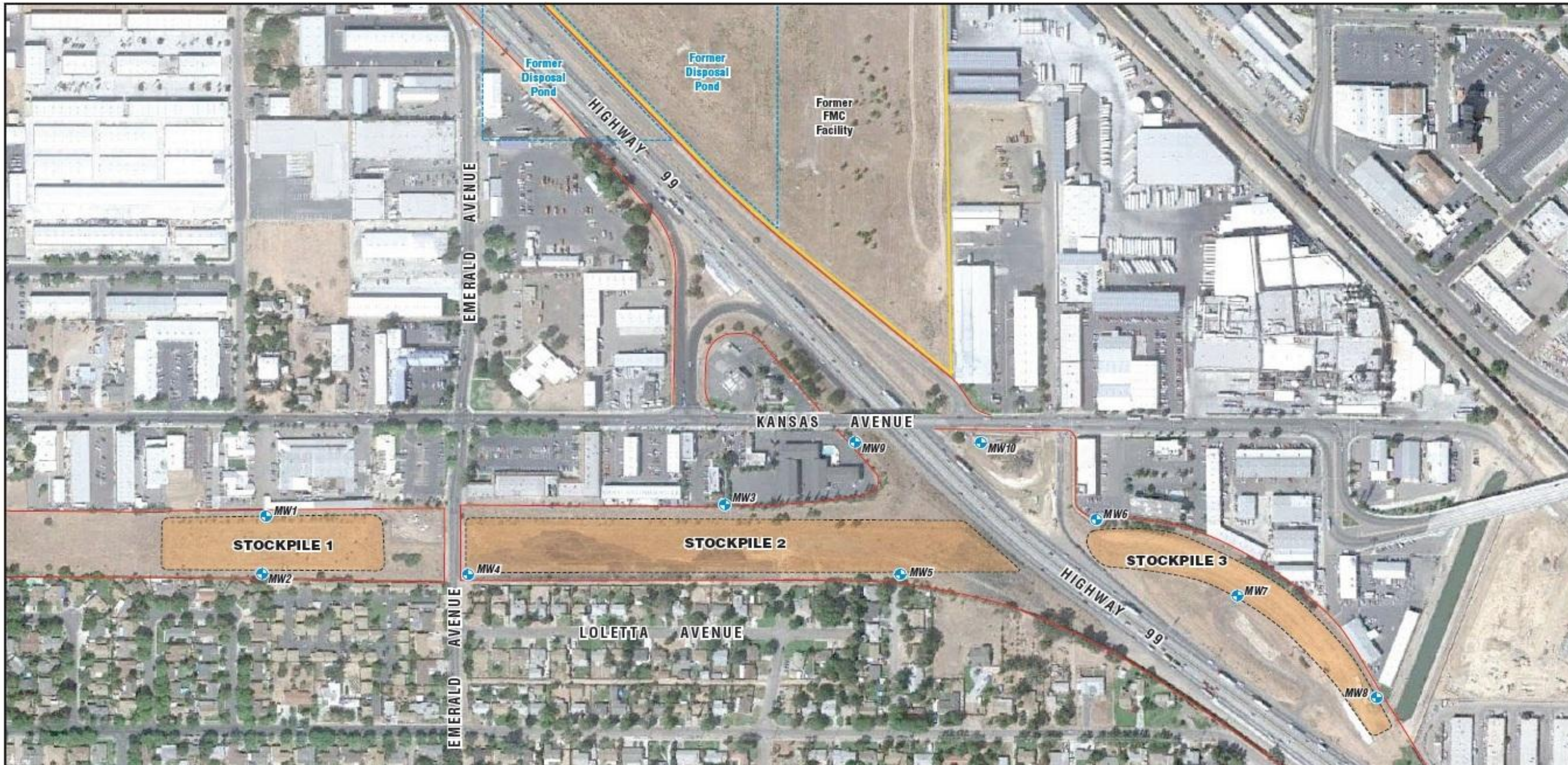
In 1961, the State of California purchased a 4.3-acre parcel at the southwest corner of the FMC site, including part of the southernmost unlined pond, for right-of-way needed to construct SR 99. During construction of SR 99, soil in and around the former FMC

pond was excavated and placed in three stockpiles within the current Caltrans right-of-way at the location of the future SR 99/SR 132 interchange project. Caltrans has installed 10 monitoring wells along the soil stockpiles and has been conducting water-quality monitoring since 2006. See Figure ES-1 for the location of the Caltrans soil stockpiles and monitoring wells.

Caltrans monitoring data for the eight constituents listed above were initially screened by comparison with background levels and historic impacts at the FMC site, and regulatory water quality standards. The initial screening determined that four constituents, TDS, sulfate, barium, and strontium, required additional detailed evaluation.

The overall evaluation and the detailed analysis of TDS, sulfate, barium, and strontium resulted in the following conclusions (abbreviated here):

1. The regional background concentrations of nitrate, barium, and strontium are elevated and the background concentrations are equivalent to or greater than concentrations observed in Caltrans monitoring wells.
2. Comparison of elevated upgradient background concentrations with those in Caltrans wells in the western part of the soil stockpiles clearly demonstrate that Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater.
3. Caltrans well MW-5, MW-6, and MW-10 typically have elevated levels of most constituents of concern. The concentrations in these wells are decreasing over time. However, over the time period during which the Caltrans wells have been monitored, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Thus, the most plausible explanation for the decreasing trends is the reduction of source mass by the FMC groundwater extraction and treatment system, demonstrating that the groundwater impacts in wells MW-5, MW-6, and MW-10 did not originate from the Caltrans soil stockpiles.
4. The concentrations in downgradient Caltrans wells MW-7 and MW-8 are lower than those in upgradient wells MW-6 and MW-10. The decreasing trends in upgradient wells MW-6 and MW-10 (Conclusion #3, above) and the lower concentrations in downgradient wells MW-7 and MW-8 demonstrate that Caltrans Stockpile 3 and the eastern part of Stockpile 2 are not impacting groundwater.
5. The data obtained from the Caltrans monitoring wells does not provide any additional insight or unique results with respect to groundwater concentrations. Therefore, it would be appropriate to substantially reduce the monitoring frequency of the Caltrans wells, or to eliminate monitoring of the Caltrans wells.



LEGEND:

MW8 Approximate Monitoring Well Location

State Right-of-Way Boundary

N

0 300
Scale in Feet

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Caltrans Modesto Soil Stockpiles	
Stanislaus County, California	
Caltrans Soil Stockpiles and Monitoring Well Locations	
May 2014	Figure ES-1

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1.0 Introduction

This report has been prepared on behalf of the California Department of Transportation (Caltrans) to evaluate groundwater data at and in the vicinity of State Route (SR) 99 and Kansas Avenue in Modesto, Stanislaus County, California (Figure 1). The objective of the study presented in this report is to develop and implement a comparative evaluation of groundwater data from the Caltrans Modesto Soil Stockpiles and FMC's Modesto barite/celestite processing plant. The comparative analysis is based primarily on various statistical parameters, such as background values calculated using the 95-percent upper confidence limit, mean concentrations, and trend analysis.

According to the Central Valley Regional Water Quality Control Board (RWQCB 1998), FMC Corporation (FMC) and its predecessors operated a chemical processing facility at 1200 Barium Road (now Graphics Drive) beginning in 1929. The facility processed barium and strontium minerals (barite and celestite) and other materials to produce a variety of industrial chemicals. From the early 1950s to the late 1970s, liquid wastes were discharged to seven unlined ponds. The FMC site has been vacant since 1985. Figure 2 shows the location of the FMC site and related groundwater monitoring wells.

Operations at the FMC site have resulted in impacts to soil and groundwater. Constituents identified in groundwater include elevated pH levels, nitrate, sulfate, sulfide, total dissolved solids, arsenic, barium, and strontium (RWQCB 1998). RWQCB issued waste discharge requirements in 1987 and Cleanup and Abatement Orders in 1993, 1996, 1997, and 1998. A groundwater extraction and treatment system began operation in 1996. Groundwater is extracted from three wells on the downgradient (east) side of the FMC site and is discharged to the local publicly-owned treatment works (POTW). Almost 1 billion gallons of groundwater have been extracted and treated since 1996 (Parsons 2014).

According to Shaw (2007), the State of California purchased a 4.3-acre parcel at the southwest corner of the FMC site in 1961 for right-of-way needed to construct SR 99. Part of the southernmost unlined pond on the FMC property was within the area purchased by the State. During construction of SR 99, soil in and around the impoundments was excavated and, according to provisions of the construction contract, stockpiled within the current Caltrans right-of-way at the location of the future SR 99/SR

132 interchange project. Three distinct stockpiles are present at the site of the interchange project (as shown on Figure 3):

- Stockpile 1, located south of Kansas Avenue and west of North Emerald Avenue;
- Stockpile 2, located south of Kansas Avenue, between North Emerald Avenue and SR 99; and
- Stockpile 3, located south of Kansas Avenue and east of SR 99.

In 2006, eight wells were installed along the stockpiles. These wells were sampled twice in 2006, bimonthly from March 2012 to January 2013, and then quarterly since that time. In 2012, two additional wells were installed just south of Kansas Avenue, one just west of SR 99 and the other just east of SR 99. These two wells were sampled five times from June 2012 to January 2013 and have been sampled quarterly since that time. The Caltrans well locations are shown on Figure 3.

According to GeoTrans (2005) and Shaw (2007), groundwater is first encountered at depths of 30 feet to 35 feet below ground surface under unconfined to semi-confined conditions. The shallow aquifer consists of interbedded and laterally discontinuous layers and lenses of sand, silt, and clay. The shallow aquifer extends to approximately 120 feet below ground surface. The hydraulic gradient within the shallow aquifer has a magnitude of 0.001 ft/ft to 0.002 ft/ft toward the southeast. Historically, however, the orientation of the hydraulic gradient may have varied from east-southeast to west-southwest due to the influence of local and regional groundwater production.

The wells installed for Caltrans in 2006 and 2012 were constructed to evaluate the potential for FMC-related constituents in the soil stockpiles to affect groundwater quality. Therefore, the Caltrans monitoring wells were screened across first-encountered groundwater. The boreholes were drilled to depths ranging from 41 feet to 48 feet below ground surface, with typically 10 feet of screen above the bottom of the borehole. The FMC wells, in contrast, were installed to evaluate the nature and extent of a known groundwater contaminant plume and to monitor the effectiveness of the groundwater extraction system. Therefore, the FMC monitoring wells were constructed with 20 feet to 30 feet of screen, with the top of the screened interval typically occurring at about 45 feet to 55 feet below ground surface, within sand and silty-sand units that are generally more continuous than those encountered at the water table (see Figure 4). The Caltrans monitoring wells were constructed for a different purpose than the FMC monitoring wells, resulting in different screen depths and intervals. These differences are appropriate given the different purposes of the wells.

2.0 Constituents of Concern

Review of site information and monitoring data for the FMC site (Parsons, 2009, 2013, 2014; RWQCB 1998) indicate that there are several constituents that have been detected in groundwater beneath the FMC site at elevated concentrations. These constituents include:

- pH;
- total dissolved solids (TDS);
- sulfate;
- sulfide;
- nitrate;
- arsenic;
- barium; and
- strontium.

The groundwater impacts at the FMC site have been attributed to past chemical processing operations at the site, including discharge of liquid waste to unlined ponds. Since at least some of the soil present in the Caltrans soil stockpiles was excavated from the area of the former unlined FMC ponds, these soils may have the potential to leach the same eight constituents listed above under certain hydrologic and geochemical conditions. Therefore, evaluation of potential impacts from the Caltrans soil stockpiles focuses on these eight constituents.

In evaluating the effects of each constituent on groundwater quality, there are several points of comparison that can potentially be used. The two primary benchmarks are associated with regulations and policies of the State Water Resources Control Board related to defining sources of drinking water and to non-degradation of waters of the state. With only rare exception, groundwater is presumed to have a beneficial use as municipal supply for human consumption. Thus, one benchmark for evaluating groundwater quality is the use of primary and secondary maximum contaminant levels (MCLs) for drinking water, drinking water health advisory levels, or similar values.

The California anti-degradation policy (State Water Resources Control Board Resolution No. 68-16) was developed to maintain high quality waters in California. The state anti-degradation policy approach goes beyond health-based criteria, such as MCLs, to consider whether an activity or a condition at a specific site will decrease water quality. The highest water quality known to exist at a site since 1968 (i.e. since the policy was enacted) defines the baseline for non-degradation. For groundwater, the baseline is often defined by identifying the background levels of site-related contaminants. Thus, a second benchmark for evaluating groundwater quality is comparison with background concentrations.

Definition of background concentrations can be challenging due to the inherent spatial variability of groundwater aquifers and differences in well construction (e.g. screen length and screened interval). Semiannual and Annual groundwater monitoring reports prepared by Parsons (e.g. 2009, 2013, 2014) for the FMC site report background concentrations for various constituents based on the 95-percent upper confidence limit (UCL) for data from 1980 through the year of each submitted report from upgradient shallow-zone well M-105. This approach presents several challenges. The first is that the background concentration changes over time. The second is that for some constituents, there are concentrations in wells outside of the influence of the FMC contamination that are higher than the reported background level for M-105. It is our understanding that FMC and its consultant are currently working to revise the approach for defining the background values for groundwater (personal communication, John Juhrend, Geocon, telephone call with Ann Palmer, RWQCB, April 24, 2014). Based on the available information and data, the background values presented in the FMC 2013 annual monitoring report (Parsons, 2014) from FMC well M-105 are used in this report as a preliminary screening tool for the evaluations presented.

3.0 Groundwater Data

Table 1 presents the laboratory analytical data from the 10 Caltrans wells located adjacent to the soil stockpiles for the FMC constituents listed above, except pH (see discussion below). Table 2 identifies, for each of the eight FMC constituents listed in Section 2.0, above, the shallow zone FMC background concentration, the typical plume range and maximum historical concentration detected in shallow zone wells on the FMC site, the Caltrans wells with mean concentrations that exceed the FMC background value, and the MCLs.

The pH value is measured in the field during purging of the Caltrans wells. The reported field pH measurements range from 5.72 to 8.13 and may vary by more than one pH unit in each individual well between different sampling events. At the FMC site, historical impacts in onsite shallow wells are very alkaline, generally ranging from a pH of 11 to 13. The FMC background concentration range is 6.52 to 8.58 (Parsons, 2014). Thus, the pH levels in the Caltrans wells are far below the levels of the historical FMC impacts and are also slightly below (i.e. slightly more acidic than) the FMC background concentration.

As shown in Table 1, TDS levels in the Caltrans wells vary from about 270 mg/L to 750 mg/L. Average TDS levels in each well range from below 400 mg/L in wells MW-2, MW-3, MW-7, and MW-8 to over 600 mg/L in wells MW-5, MW-6, and MW-10. At the FMC site, historical impacts in onsite shallow wells generally range from 3000 mg/L to 6000 mg/L. The FMC background concentration is 530 mg/L (Parsons, 2014). The TDS levels in the Caltrans wells do not show a consistent pattern of higher or lower concentrations in either upgradient or downgradient wells. For example, low-TDS wells MW-2, MW-7, and MW-8 are generally downgradient of the soil stockpiles, while low-TDS well MW-3 is generally upgradient. Similarly, high-TDS wells MW-6 and MW-10 are generally upgradient of the soil stockpiles, while high-TDS well MW-5 is generally downgradient. The TDS levels in all of the Caltrans wells are far below the historical impacts at the FMC site, even though three Caltrans wells have average TDS levels that exceed the FMC background concentration (see Table 2).

Sulfate concentrations in the Caltrans wells vary from less than 10 mg/L to 120 mg/L, with the highest concentrations occurring in upgradient wells MW-6 and MW-10 (see Table 1). Average sulfate concentrations in each well range from below 15 mg/L in wells MW-2 and MW-3 to 66.2 mg/L in well MW-6 and 88.3 in well MW-10. At the FMC site, historical impacts in onsite shallow wells exceed 1000 mg/L. The FMC background concentration is 43 mg/L (Parsons, 2014). The sulfate levels in the Caltrans wells are substantially less than the historical impacts at the FMC site, while upgradient wells MW-6 and MW-10 have average sulfate concentrations that exceed the FMC background concentration (see Table 2).

Sulfide in groundwater in the vicinity of the FMC site is most likely present due to the reduction of sulfate. As a result, sulfide will only persist at high concentrations in wells with a negative oxidation-reduction potential, indicating reducing conditions in groundwater. Reducing conditions have not been measured in the Caltrans wells, but do occur in parts of the FMC site. The highest average sulfide concentrations in the Caltrans wells occur in upgradient wells MW-1 and MW-10. As shown in Tables 1 and 2, the concentrations of sulfide in the Caltrans wells, when detected, are far below both the FMC background concentration and the historical levels of over 300 mg/L found at the FMC site.

Nitrate concentrations, reported as nitrogen (i.e. NO_3-N), in the Caltrans wells vary from less than 3 mg/L to 36 mg/L, with the highest concentrations occurring in downgradient well MW-5 and upgradient wells MW-6 and MW-10 (see Table 1). Average nitrate concentrations in each well range from below 5 mg/L in wells MW-3 and MW-7 to greater than the MCL of 10 mg/L in wells MW-1, MW-5, MW-6, and MW-10. At the FMC site, historical impacts in onsite shallow wells exceed 100 mg/L. The FMC background concentration is 20.4 mg/L (Parsons, 2014). While the historical data indicate that shallow groundwater at the FMC site had been impacted by elevated levels of nitrate in the 1980s, the data also demonstrate that there is a regional nitrate issue in the area. The regional nitrate issue is evidenced by the elevated concentrations (exceeding the MCL of 10 mg/L) in FMC background well M-105, in offsite FMC wells M-153 and M-154, and in upgradient Caltrans wells MW-1, MW-6, and MW-10.

As shown in Table 1, arsenic concentrations in the Caltrans wells are consistently low, with average concentrations below 5.0 μg/L in all wells. At the FMC site, historical arsenic impacts in onsite shallow wells range from 200 μg/L to 400 μg/L. The FMC background concentration is 5.7 μg/L (Parsons, 2014). The highest arsenic concentrations in the Caltrans wells occur in upgradient wells MW-3 and MW-6, but even the levels in these wells are below the FMC background concentration.

Barium concentrations in the Caltrans wells range from 32 μg/L in well MW-3 to 410 μg/L in well MW-5. Average concentrations are below 130 μg/L in all wells except MW-5, which has an average barium concentration of 309 μg/L. Although barite (barium sulfate) was one of the primary minerals processed at the FMC site, and present in FMC soils, a persistent elevated barium plume in groundwater has not been identified. FMC wells with slightly elevated barium levels have had concentrations in the range of 200 μg/L to 300 μg/L, with a background concentration of 220 μg/L and a peak concentration of 600 μg/L (Parsons, 2014). The background concentration and peak concentration at FMC differ by less than a factor of three. In contrast, for TDS, sulfate, sulfide, nitrate, and arsenic, the background concentration and the peak concentration typically differ by a factor of 10 to 50 or more. Currently, the highest barium concentrations in FMC monitoring wells occur at locations upgradient of or side-gradient to the FMC site, and several thousand feet away from the FMC site. These wells include M-113, M-121, M-153, M-154, and M-159, with recent concentrations in the range of approximately 150 μg/L to 250 μg/L.

Strontium concentrations in the Caltrans wells range from 210 μg/L in well MW-8 to 1200 μg/L in wells MW-1 and MW-5. Average concentrations are below 800 μg/L in wells MW-2, MW-3, MW-6, MW-7, MW-8, and MW-9. Average concentrations exceed 1,000 μg/L in MW-1, MW-5, and MW-10. At the FMC site, historical strontium impacts in onsite shallow wells range from 1000 μg/L to 2000 μg/L. The FMC background concentration is 830 μg/L (Parsons, 2014). Similar to barium, the highest strontium concentrations over the past several years occur in FMC monitoring wells at locations upgradient of or side-gradient to the FMC site, and several thousand feet away from the

FMC site. These wells include M-113, M-121, M-153, and M-154, with recent concentrations in the range of approximately 1000 μg/L to 1500 μg/L.

4.0 Data Evaluation

In this section, each of the eight FMC constituents listed in Section 2.0 is initially screened for the potential to affect groundwater quality based on the discussion presented in Section 3.0, above. Based on the initial screening, additional detailed data evaluation is conducted for four of the constituents of concern, as described below.

4.1 Initial Screening

At the FMC site, historical operations created groundwater conditions that were strongly alkaline, whereas background conditions are slightly acidic to slightly alkaline. In the Caltrans wells, the pH range is slightly more acidic than the background range for the FMC site. Therefore, the data demonstrate that the Caltrans stockpiles are not affecting the pH of the groundwater and no further analysis is necessary for this constituent.

Three of the Caltrans wells, MW-5, MW-6, and MW-10, have average TDS levels that exceed the FMC background concentration and the secondary MCL. While the TDS levels in the Caltrans wells are far below the range of historical impacts at the FMC site, further detailed evaluation of TDS related to the Caltrans soil stockpiles is presented below.

Two of the Caltrans wells, MW-6 and MW-10, have average sulfate concentrations that exceed the FMC background concentration but are well below the secondary MCL. Sulfate, however, is one of the most soluble and mobile constituents present in the FMC wastes. Therefore, sulfate is retained for further detailed evaluation of potential impacts to groundwater from the Caltrans soil stockpiles.

Sulfide is not present above the FMC background concentration in any of the Caltrans wells. Furthermore, reducing conditions (i.e. negative ORP values) do not exist in the groundwater beneath the Caltrans soil stockpiles. The absence of reducing conditions indicates that formation or persistence of sulfide is geochemically improbable. Thus, no further evaluation is necessary for sulfide.

Nitrate is present above the FMC background concentration in only one Caltrans well, MW-5. As discussed in Section 3.0, above, nitrate is elevated regionally in the FMC/Caltrans site vicinity, as evidenced by the background concentration of more than twice the MCL, elevated nitrate levels in upgradient Caltrans well MW-1 (which is not downgradient of the FMC site), and elevated nitrate levels in offsite FMC wells M-153 and M-154. The nitrate data also have a high degree of spatial variability in the FMC and Caltrans wells. Further evaluation of nitrate is not conducted due to the regional nature of the nitrate distribution and the occurrence of nitrate in offsite FMC wells at concentrations comparable to those detected at MW-5.

Arsenic is not present in any of the Caltrans wells at concentrations that exceed the FMC background or the MCL. Therefore, no further evaluation of arsenic is needed.

Barium is present above the FMC background concentration only in Caltrans well MW-5. As discussed in Section 3.0, above, although barite (barium sulfate) was one of the primary minerals processed at the FMC site, and present in FMC soils, a persistent elevated barium plume in groundwater has not been identified. In addition, the highest current barium concentrations in FMC monitoring wells occur at locations upgradient or side-gradient to the FMC site, and several thousand feet away from the FMC site. Thus, similar to nitrate, there appears to be a regional barium occurrence. However, given that there is residual barite and/or barium present in the soils in the Caltrans soil stockpiles, barium is retained for further detailed evaluation of potential impacts to groundwater from the Caltrans soil stockpiles.

Strontium is present above the FMC background concentration in four Caltrans wells, MW-1, MW-4, MW-5, and MW-10. Similar to barium, the highest strontium concentrations over the past several years occur in FMC monitoring wells at locations upgradient of or side-gradient to the FMC site, and several thousand feet away from the FMC site. However, also like barium, there is residual celestite and/or strontium present in the soils in the Caltrans soil stockpiles. Therefore, strontium is retained for further detailed evaluation.

4.2 Detailed Evaluation

As discussed in Section 4.1, above, detailed evaluation of TDS, sulfate, barium, and strontium are presented in this section.

4.2.1 TDS

Figure 5 shows the TDS levels in the Caltrans and FMC shallow zone wells for January 2013. This is the most recent month during which both sets of wells have been sampled. As discussed in Section 1.0, the hydraulic gradient and thus the presumed direction of groundwater flow is oriented toward the southeast. Upgradient Caltrans well MW-1 has a higher TDS level than wells MW-2, MW-3 and MW-4, downgradient to the southeast. In addition, FMC well M-154, upgradient of MW-1, has a higher TDS level than the four Caltrans wells discussed in this paragraph, above. Thus, Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater with TDS.

The highest TDS levels shown on Figure 5 extend from FMC wells M-103 and M-2R southeast across the FMC site and downgradient to wells M-109, M-111, and M-101. The TDS levels in these FMC wells range from 2,830 mg/L in M-106 to 825 mg/L in M-101. To the south and southeast, Caltrans wells MW-5, MW-6, and MW-10 have TDS levels ranging from 680 mg/L to 600 mg/L to 610 mg/L, respectively. Based on the well locations, it appears that the TDS impacts in these three Caltrans wells are coming from the FMC site. Farther downgradient, TDS levels in Caltrans wells MW-7 and MW-8 are lower than those upgradient in MW-6 and MW-10. Thus, Caltrans Stockpile 3 and the eastern part of Stockpile 2 do not appear to be impacting groundwater with TDS.

Figure 6 shows the TDS levels in the Caltrans wells over time. In addition, this figure shows the FMC background concentration and the secondary MCL value. Linear trend lines have also been plotted for MW-1, MW-5, MW-6, and MW-10. For MW-1, at the western edge of the Caltrans soil stockpiles, the trend over the last eight years has been flat, indicative of a consistent upgradient regional TDS, unaffected by a contaminant source such as the FMC site. In contrast, the trend in MW-5, MW-6, and MW-10 is decreasing over time. Over the time period shown on Figure 6, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Thus, the decreasing trend in wells MW-5, MW-6, and MW-10 is most likely attributable to the groundwater extraction and treatment occurring at the FMC site, which is reducing mass in the groundwater source area, leading to lower concentrations over time at and downgradient of the FMC site.

The TDS distribution and the comparative difference between the stable TDS levels in MW-1 versus the decreasing TDS levels in MW-5, MW-6, and MW-10 clearly indicate that the elevated TDS levels in MW-5, MW-6, and MW-10 is a result of downgradient migration from the FMC site and not due to the Caltrans stockpiles.

4.2.2 Sulfate

Figure 7 shows the sulfate levels in the Caltrans and FMC shallow zone wells for January 2013. This is the most recent month during which both sets of wells have been sampled. As discussed in Section 1.0, the hydraulic gradient and thus the presumed direction of groundwater flow is oriented toward the southeast. Upgradient Caltrans well MW-1 has a higher sulfate concentration than wells MW-2, MW-3 and MW-4, downgradient to the southeast. In addition, FMC well M-154, upgradient of MW-1, has a sulfate concentration that is slightly higher than or equivalent to the concentration in the four Caltrans wells discussed in this paragraph, above. Thus, Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater with sulfate.

The highest sulfate concentrations shown on Figure 7 extend from FMC wells M-103 and M-2R southeast across the FMC site and downgradient to wells M-109, M-111, and M-101. The sulfate concentrations in these FMC wells range from 1,150 mg/L in M-104 to 188 mg/L in M-101. To the south and southeast, Caltrans wells MW-5, MW-6, and MW-10 have sulfate concentrations ranging from 26 mg/L to 65 mg/L to 83 mg/L, respectively. Based on the well locations, it appears that the sulfate impacts in these three Caltrans wells are coming from the FMC site. Farther downgradient, sulfate concentrations in Caltrans wells MW-7 and MW-8 are lower than those upgradient in MW-6 and MW-10. Thus, Caltrans Stockpile 3 and the eastern part of Stockpile 2 do not appear to be impacting groundwater with sulfate.

Figure 8 shows the sulfate concentrations in the Caltrans wells over time. This figure also shows the FMC background concentration and the secondary MCL value. Linear trend lines have also been plotted for MW-1, MW-5, MW-6, and MW-10. For MW-1, at the western edge of the Caltrans soil stockpiles, the trend over the last eight years has been slightly increasing, indicative of a minor upgradient drift in the regional sulfate levels. In contrast, the trend in MW-5, MW-6, and MW-10 is decreasing over time. Over the time period shown on Figure 8, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Comparable to the TDS trend discussed above, the decreasing sulfate trend in wells MW-5, MW-6, and MW-10 is most likely attributable to the groundwater extraction and treatment occurring at the FMC site, which is reducing mass in the groundwater source area, leading to lower concentrations over time at and downgradient of the FMC site.

The sulfate distribution and the comparative difference between the slightly increasing sulfate concentrations in MW-1 and the decreasing sulfate concentrations in MW-5, MW-6, and MW-10 clearly indicate that the elevated sulfate in MW-5, MW-6, and MW-10 is a result of downgradient migration from the FMC site and not due to the Caltrans stockpiles.

4.2.3 Barium

Figure 9 shows the barium levels in the Caltrans and FMC shallow zone wells for January 2013. This is the most recent month during which both sets of wells have been sampled. As discussed in Section 1.0, the hydraulic gradient and thus the presumed direction of groundwater flow is oriented toward the southeast. Upgradient Caltrans well MW-1 has a higher barium concentration than wells MW-2, MW-3 and MW-4, downgradient to the southeast. In addition, FMC well M-154, upgradient of MW-1, has a barium concentration that is higher than the concentration in the four Caltrans wells discussed in this paragraph, above. Thus, Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater with barium.

As discussed in Section 3.0, a persistent elevated barium plume in groundwater has not been identified on the FMC site. FMC wells with slightly elevated barium levels have had concentrations in the range of 200 μg/L to 300 μg/L, with a background concentration of 220 μg/L and a peak concentration of 600 μg/L (Parsons, 2014). Currently, the highest barium concentrations in FMC monitoring wells occur at locations upgradient of or side-gradient to the FMC site, and several thousand feet away from the FMC site. These wells include M-113, M-121, M-153, M-154, and M-159, with January 2013 concentrations in the range of 130 μg/L to 210 μg/L. In the Caltrans wells, the highest barium concentrations occur in MW-5 and MW-6, with the concentration in upgradient well MW-10 being midway between those in FMC well M-101 and Caltrans well MW-6. The concentration in MW-5 is comparable to historical levels at the FMC site.

Figure 10 shows the barium concentrations in the Caltrans wells over time. This figure also shows the FMC background concentration and the EPA drinking water health advisory (which is lower than the MCL for barium). Linear trend lines have also been plotted for MW-1, MW-5, MW-6, and MW-10. For MW-1, at the western edge of the Caltrans soil stockpiles, the trend over the last eight years has been relatively flat to slightly increasing, indicative of a very minor upgradient drift in the regional barium levels. In contrast, the trend in MW-5, MW-6, and MW-10 is decreasing over time. Over the time period shown on Figure 10, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Comparable to the TDS and sulfate trends discussed above, the decreasing barium trend in wells MW-5, MW-6, and MW-10 is most likely attributable to the groundwater extraction and treatment occurring at the FMC site.

The barium distribution and the comparative difference between the very slightly increasing barium concentrations in MW-1 and the decreasing barium concentrations in MW-5, MW-6, and MW-10 indicate that the elevated barium in MW-5, M-6, and MW-10 is a result of downgradient migration from the FMC site, and not due to the Caltrans stockpiles. Furthermore, the decades of operation at the FMC site, including the discharge of wastes to unlined ponds and the substantial presence of barite in soils at the FMC site, did not result in widespread and persistent impacts to groundwater from barium. Therefore, it is highly unlikely that the Caltrans soil stockpiles would have a substantial effect on groundwater with respect to barium.

4.2.4 Strontium

Figure 11 shows the strontium levels in the Caltrans and FMC shallow zone wells for January 2013. This is the most recent month during which both sets of wells have been sampled. As discussed in Section 1.0, the hydraulic gradient and thus the presumed direction of groundwater flow is oriented toward the southeast. Upgradient Caltrans well MW-1 has a higher strontium concentration than wells MW-2, MW-3 and MW-4, downgradient to the southeast. In addition, FMC well M-154, upgradient of MW-1, has a strontium concentration that is higher than the concentration in the four Caltrans wells discussed in this paragraph, above. Thus, Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater with strontium.

The highest strontium concentrations on the FMC site (see Figure 11) extend along the eastern property line, with the highest concentration (680 μg/L) occurring in well M-101. To the south and southeast, Caltrans wells MW-5, MW-6, and MW-10 have strontium concentrations ranging from 1,200 μg/L to 620 μg/L to 1,200 μg/L, respectively. Based on the well locations, it appears that the strontium in these three Caltrans wells represents a residual impact from the FMC site. Farther downgradient, strontium concentrations in Caltrans wells MW-7 and MW-8 are lower than those upgradient in MW-10. Thus, Caltrans Stockpile 3 and the eastern part of Stockpile 2 do not appear to be impacting groundwater with strontium.

Figure 12 shows the strontium concentrations in the Caltrans wells over time. This figure also shows the FMC background concentration. To accommodate the tight distribution of the data, the vertical axis of the graph in Figure 12 only extends to one half of the EPA drinking water health advisory of 4,000 μg/L (there is no MCL for strontium). Linear trend lines have also been plotted for MW-1, MW-5, MW-6, and MW-10. For MW-1, at the western edge of the Caltrans soil stockpiles, the trend over the last eight years has been slightly increasing, indicative of a minor upgradient drift in the regional strontium levels. In contrast, the trend in MW-5, MW-6, and MW-10 is decreasing over time. Over the time period shown on Figure 12, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Comparable to the trends for TDS, sulfate, and barium discussed above, the decreasing strontium trend in wells MW-5, MW-6, and MW-10 is most likely attributable to the groundwater extraction and treatment occurring at the FMC site.

The strontium distribution and the comparative difference between the slightly increasing strontium concentrations in MW-1 and the decreasing strontium concentrations in MW-5, MW-6, and MW-10 clearly indicate that the elevated strontium in MW-5, MW-6, and MW-10 is a result of downgradient migration from the FMC site and not due to the Caltrans stockpiles.

5.0 Conclusions

Based on the data evaluation and discussion presented above, the following conclusions can be made:

1. There is a regional distribution, or background, of several constituents at concentrations that are equivalent to or greater than those observed in Caltrans monitoring wells. This elevated regional background is observed in wells upgradient and sidegradient of the FMC site, including wells M-153, M-154, and M-159. Regionally elevated background levels appear to occur for nitrate, barium, and strontium.
2. Comparison of elevated upgradient background concentrations with those in Caltrans wells MW-1, MW-2, MW-3, and MW-4, and the trend over time in MW-1, clearly demonstrates that Caltrans Stockpile 1 and the western part of Stockpile 2 are not impacting groundwater.
3. Caltrans well MW-5, MW-6, and MW-10 typically have elevated levels of most constituents of concern. The concentrations in these wells are decreasing over time. However, over the time period during which the Caltrans wells have been monitored, there have been no changes to the conditions at the Caltrans soil stockpiles that would affect contaminant source mass or leaching. Thus, the most plausible explanation for the decreasing trends is the reduction of source mass by the FMC groundwater extraction and treatment system, demonstrating that the groundwater impacts in wells MW-5, MW-6, and MW-10 did not originate from the Caltrans soil stockpiles.
4. The concentrations in downgradient Caltrans wells MW-7 and MW-8 are lower than those in upgradient wells MW-6 and MW-10. The decreasing trends in upgradient wells MW-6 and MW-10 (Conclusion #3, above) and the lower concentrations in downgradient wells MW-7 and MW-8 demonstrate that Caltrans Stockpile 3 and the eastern part of Stockpile 2 are not impacting groundwater.
5. The data obtained from the Caltrans monitoring wells does not provide any additional insight or unique results with respect to groundwater concentrations. Stated another way, the Caltrans data would not significantly alter contour maps of constituent concentrations that could be drawn using only FMC data. For example, the concentrations in Caltrans wells MW-1, MW-2, and MW-4 are typically between the concentrations measured in FMC wells M-154 and M-157. Likewise, the concentrations in Caltrans wells MW-6 and MW-10 are typically between the concentrations measured in FMC wells M-101 and M-113.

Therefore, it would be appropriate to substantially reduce the monitoring frequency of the Caltrans wells, or to eliminate monitoring of the Caltrans wells.

6.0 References Cited

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TABLES

TABLE 1

CALTRANS LABORATORY ANALYTICAL DATA

Caltrans Modesto Soil Stockpiles

Well	Sample Date	TDS	SO_4	SULFIDE	NO_3-N	As	Ba	Sr
		mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MW-1	6/14/2006	---	18	<0.1	5.0	2.1	130	---
MW-1	10/5/2006	500	18	<0.1	6.8	2.2	120	---
MW-1	3/12/2012	550	16	<0.05	12	<5.0	120	960
MW-1 S	3/12/2012	453	15.6	0.0637	11.4	*1.6*	*105*	*1,010*
MW-1	5/17/2012	480	16	0.1	12	2.3	150	1,100
MW-1	7/16/2012	540	20	0.1	12	2.2	130	1,100
MW-1	9/19/2012	460	25	0.28	12	2.1	120	1,100
MW-1	11/28/2012	420	19	0.12	12	2.2	140	1,100
MW-1	1/22/2013	460	20	0.52	12	2.0	110	1,100
MW-1	3/18/2013	500	18	0.18	13	3.3	190	1,000
MW-1	6/5/2013	520	18	<0.05	12	2.2	110	1,000
MW-1	9/4/2013	590	29	0.28	12	2.4	130	1,200
MW-1	12/11/2013	500	28	<0.05	13	1.8	120	1,200
MW-1	2/25/2014	460	24	<0.010	10	1.9	110	920
Average		*495*	*20.3*	*0.21*	*11.1*	*2.2*	*128*	*1066*
MW-2	6/13/2006	---	21	<0.1	5.5	2.1	87	---
MW-2	10/5/2006	390	16	<0.1	6.1	2.6	84	---
MW-2	3/12/2012	460	16	0.06	9.0	<5.0	88	610
MW-2 S	3/12/2012	382	15.2	0.0497	8.77	*<10*	*89.6*	*642*
MW-2	5/17/2012	400	14	0.07	7.5	2.6	89	700
MW-2	7/16/2012	410	13	0.042	7.2	3.1	100	740
MW-2	9/19/2012	390	14	0.10	7.3	2.5	88	650
MW-2	11/28/2012	390	14	0.07	7.5	2.6	88	640
MW-2	1/22/2013	360	13	0.04	6.9	2.7	87	680
MW-2	3/18/2013	390	11	<0.020	6.2	2.6	83	580
MW-2	6/5/2013	350	11	0.073	6.1	2.5	84	620
MW-2	9/4/2013	400	15	<0.020	9.0	3.2	85	640
MW-2	12/11/2013	380	16	0.033	8.9	2.2	72	530
MW-2	2/25/2014	390	13	<0.010	7.4	2.5	80	570
Average		*392*	*14.4*	*0.06*	*7.4*	*2.6*	*86*	*634*
MCLs		500 (1)	250 (1)	---	10	10	1000/ 700 (2)	4,000 (2)

TABLE 1 (continued)
CALTRANS LABORATORY ANALYTICAL DATA
Caltrans Modesto Soil Stockpiles

Well	Sample Date	TDS	SO_4	SULFIDE	NO_3-N	As	Ba	Sr
		mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MW-3	6/13/2006	---	18	<0.1	5.4	3.0	60	---
MW-3	10/5/2006	340	17	<0.1	5.0	3.3	58	---
MW-3	3/12/2012	400	17	0.09	2.9	<5.0	58	390
MW-3 S	3/12/2012	273	13.8	0.0281	2.24	*2.1*	*44.4*	*342*
MW-3	5/17/2012	300	14	0.05	2.5	3.8	64	490
MW-3	7/16/2012	400	17	0.014	2.8	2.2	240	840
MW-3	9/19/2012	350	18	<0.05	3.0	4.6	84	560
MW-3	11/28/2012	380	12	0.062	2.8	4.6	60	430
MW-3	1/22/2013	330	9.9	0.034	2.9	5.5	55	430
MW-3	3/18/2013	340	9.4	<0.010	2.7	5.2	43	300
MW-3	6/6/2013	360	9.6	<0.010	3.3	4.8	45	350
MW-3	9/4/2013	300	6.4	0.011	2.5	5.8	36	260
MW-3	12/11/2013	270	7.1	<0.020	2.4	5.4	34	240
MW-3	2/25/2014	340	9.1	<0.010	2.8	5.1	48	300
Average		*337*	*12.7*	*0.04*	*3.1*	*4.3*	*66*	*411*
MW-4	6/13/2006	---	15	<0.1	3.5	1.8	130	---
MW-4	10/4/2006	340	11	<0.1	3.5	2.1	100	---
MW-4	3/12/2012	530	23	0.05	9.5	<5.0	160	840
MW-4 S	3/12/2012	472	21.8	0.172	9.59	*1.4*	*134*	*812*
MW-4	5/17/2012	540	23	0.09	10	2.1	160	960
MW-4	7/16/2012	430	20	<0.010	8.2	6.6	110	850
MW-4	9/19/2012	480	23	0.085	8.2	2.2	140	980
MW-4	11/28/2012	500	26	0.06	8.9	2.1	140	920
MW-4	1/22/2013	370	18	0.054	7.2	1.8	100	850
MW-4	3/18/2013	380	18	0.022	7.1	2.0	110	780
MW-4	6/5/2013	420	19	0.045	7.1	2.0	120	900
MW-4	9/4/2013	510	26	0.019	10	2.7	140	890
MW-4	12/11/2013	510	26	0.040	9.6	1.8	110	830
MW-4	2/25/2014	490	26	<0.010	9.5	1.9	130	810
Average		*459*	*21.1*	*0.06*	*8.0*	*2.3*	*127*	*869*
MCLs		500 (1)	250 (1)	---	10	10	1000/ 700 (2)	4,000 (2)

TABLE 1 (continued)
CALTRANS LABORATORY ANALYTICAL DATA
Caltrans Modesto Soil Stockpiles

Well	Sample Date	TDS	SO_4	SULFIDE	NO_3-N	As	Ba	Sr
		mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MW-5	6/14/2006	---	37	<0.1	8.3	1.8	400	---
MW-5	10/5/2006	730	32	<0.1	10	2.5	410	---
MW-5	3/12/2012	700	33	<0.05	27	<5.0	340	1,200
MW-5 S	3/12/2012	632	30.4	0.0778	25.4	*1.3*	*310*	*1,140*
MW-5	5/17/2012	690	38	0.08	26	2.4	310	1,400
MW-5	7/17/2012	620	26	<0.05	20	2.8	280	1,100
MW-5	*9/20/2012*	*590*	*26*	*0.015*	*22*	2.3	280	1,100
MW-5	11/29/2012	640	25	0.09	24	2.9	300	960
MW-5	1/23/2013	680	26	0.022	30	1.7	310	1,200
MW-5	3/18/2013	700	26	<0.010	30	2.3	300	1,100
MW-5	6/6/2013	530	20	<0.020	17	2.2	230	940
MW-5	9/5/2013	750	28	0.012	36	1.7	320	1100
MW-5	12/12/2013	630	26	0.011	25	2.2	230	790
MW-5	2/25/2014	750	27	<0.010	34	2.4	310	920
Average		*665*	*28.6*	*0.04*	*23.9*	*2.2*	*309*	*1079*
MW-6	6/14/2006	---	70	<0.1	12	3.6	160	---
MW-6	10/4/2006	700	76	<0.1	15	5.2	120	---
MW-6	3/12/2012	680	75	0.05	18	<5.0	99	680
MW-6 S	3/12/2012	613	72.0	0.0788	17.7	*2.8*	*94.2*	*655*
MW-6	5/17/2012	630	66	0.07	18	3.9	93	690
MW-6	7/17/2012	590	70	<0.05	19	6.3	110	1,100
MW-6	9/20/2012	610	65	0.13	18	4.7	110	860
MW-6	11/29/2012	610	66	0.061	18	5.1	98	760
MW-6	1/23/2013	600	65	0.065	18	4.2	120	620
MW-6	3/18/2013	600	62	0.082	17	4.6	79	610
MW-6	6/6/2013	620	67	0.020	20	4.3	76	650
MW-6	9/5/2013	620	61	0.062	16	3.3	90	640
MW-6	12/12/2013	580	56	0.11	16	4.4	130	590
MW-6	2/26/2014	570	56	<0.010	15	4.1	80	590
Average		*617*	*66.2*	*0.07*	*17.0*	*4.3*	*104*	*704*
MCLs		500 (1)	250 (1)	---	10	10	1000/ 700 (2)	4,000 (2)

TABLE 1 (continued)
CALTRANS LABORATORY ANALYTICAL DATA
Caltrans Modesto Soil Stockpiles

Well	Sample Date	TDS	SO_4	SULFIDE	NO_3-N	As	Ba	Sr
		mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MW-7	6/14/2006	---	29	<0.1	3.0	2.3	80	---
MW-7	10/4/2006	370	26	<0.1	3.1	2.7	73	---
MW-7	3/12/2012	360	26	<0.05	3.0	<5.0	76	690
MW-7	5/17/2012	280	18	0.1	2.5	2.3	63	590
MW-7	7/17/2012	300	24	0.07	3.3	2.2	66	600
MW-7	9/20/2012	320	22	<0.10	3.6	3.1	96	900
MW-7	11/29/2012	340	28	0.069	3.4	2.5	77	690
MW-7	1/23/2013	310	22	0.017	3.4	2.9	68	670
MW-7	3/18/2013	290	20	0.033	3.0	4.0	150	650
MW-7	6/6/2013	340	22	0.022	3.9	2.7	66	690
MW-7	9/5/2013	350	22	<0.010	4.1	1.4	78	650
MW-7	12/12/2013	410	31	<0.020	4.2	2.2	78	740
MW-7	2/26/2014	340	25	<0.010	4.2	2.9	79	720
Average		*334*	*24.2*	*0.05*	*3.4*	*2.6*	*81*	*690*
MW-8	6/14/2006	---	26	<0.1	9.2	2.7	84	---
MW-8	10/4/2006	360	21	<0.1	7.8	4.0	57	---
MW-8	3/12/2012	330	25	0.05	6.7	<5.0	39	180
MW-8 S	3/12/2012	253	25.2	0.0194	5.31	*2.5*	*39.4*	*211*
MW-8	5/17/2012	390	32	0.07	6.3	3.2	55	270
MW-8	7/17/2012	390	32	0.05	5.2	3.2	51	210
MW-8	9/20/2012	280	19	0.031	5.9	3.9	47	220
MW-8	11/29/2012	390	32	<0.05	11	4.0	110	450
MW-8	1/23/2013	420	26	0.014	3.6	4.2	57	260
MW-8	3/18/2013	340	22	0.010	4.2	4.0	56	250
MW-8	6/6/2013	380	35	0.023	4.8	3.8	51	250
MW-8	9/5/2013	370	21	<0.010	7.1	2.5	67	300
MW-8	12/12/2013	370	16	<0.020	4.3	2.8	61	340
MW-8	2/26/2014	350	21	<0.010	3.6	4.0	55	260
Average		*356*	*25.2*	*0.03*	*6.1*	*3.4*	*59*	*267*
MCLs		500 (1)	250 (1)	---	10	10	1000/ 700 (2)	4,000 (2)

TABLE 1 (continued)
CALTRANS LABORATORY ANALYTICAL DATA
Caltrans Modesto Soil Stockpiles

Well	Sample Date	TDS	SO_4	SULFIDE	NO_3-N	As	Ba	Sr
		mg/L	mg/L	mg/L	mg/L	μg/L	μg/L	μg/L
MW-9	6/20/2012	510	27	0.07	13	2.3	67	840
MW-9	7/17/2012	350	25	0.14	11	2.7	51	800
MW-9	9/19/2012	470	25	<0.05	11	3.1	100	970
MW-9	11/28/2012	440	22	<0.05	9.0	3.2	100	820
MW-9	1/22/2013	430	22	0.035	8.5	2.6	90	710
MW-9	3/18/2013	450	22	0.015	8.8	3.1	92	700
MW-9	6/6/2013	490	23	<0.010	12	2.8	99	770
MW-9	9/5/2013	450	22	<0.010	7.0	2.3	110	690
MW-9	12/12/2013	520	26	0.021	11	2.4	110	780
MW-9	2/26/2014	460	19	<0.010	7.7	3.3	120	730
Average		*457*	*23.3*	*0.06*	*9.9*	*2.8*	*94*	*781*
MW-10	6/20/2012	710	120	<0.05	9.2	4.1	160	990
MW-10	7/17/2012	710	110	0.18	9.8	2.8	59	1,000
MW-10	9/20/2012	630	99	0.011	14	2.7	83	1,100
MW-10	11/29/2012	640	98	0.089	16	3.1	76	970
MW-10	1/22/2013	*610*	*83*	*0.022*	*18*	3.8	86	1,200
MW-10	3/18/2013	620	77	0.027	17	3.5	78	930
MW-10	6/6/2013	620	83	0.35	20	3.1	68	1,000
MW-10	9/5/2013	610	75	0.015	17	1.8	86	910
MW-10	12/12/2013	610	70	0.19	18	2.8	83	950
MW-10	2/26/2014	630	68	<0.010	18	3.4	120	970
Average		*639*	*88.3*	*0.11*	*15.7*	*3.1*	*90*	*1002*
MCLs		500 (1)	250 (1)	---	10	10	1000/ 700 (2)	4,000 (2)

Notes: *S* = Split samples submitted by the Central Valley Regional Water Quality Control Board to Excelchem Environmental Labs.
< = Less than the indicated laboratory reporting limit
--- = Not analyzed or not applicable
MCLs = Maximum Contaminant Levels per California Environmental Protection Agency, May 2009
(1) = Secondary MCL
(2) = EPA Drinking Water Health Advisory

TABLE 2

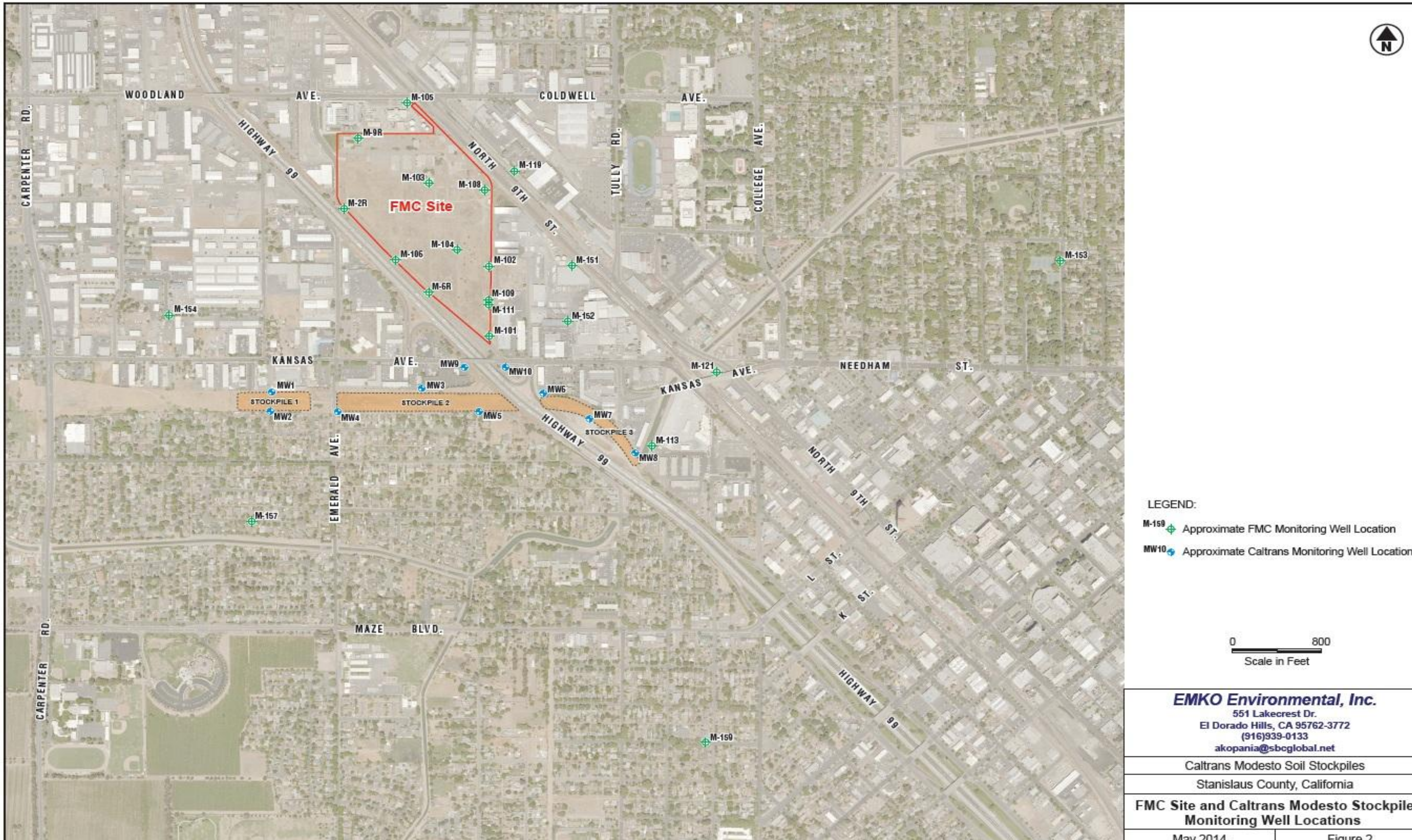
COMPARISON OF FMC AND CALTRANS GROUNDWATER DATA

Caltrans Modesto Soil Stockpiles

Parameter	Units	FMC Groundwater Data (1980-2013)					Caltrans Groundwater Data (2006-2014)		Water Quality Standard
		Typical Range of Historical Impacts	Maximum Historical Concentration	Well	Date	Background (M-105)	Wells Exceeding Background	Average Concentration	
pH	std units	11 - 13	13.41	M-104	7/24/1997	6.52-8.58	None	NA	6.0-8.0
TDS	mg/L	3000 - 6000	9954	M-106	1/15/1981	530	MW-5	665	500
							MW-6	617	
							MW-10	639	
SO_4	mg/L	>1000	2990	M-2R	6/10/1982	43	MW-6	66	250
							MW-10	88	
Sulfide	mg/L	>300	1241	M-103	6/8/1983	0.45	None	NA	NA
NO_3-N	mg/L	>100	455	M-6R	11/18/1981	20.4	MW-5	24	10
As	µg/L	200 - 400	520	M-109	6/7/1983	5.7	None	NA	10
Ba	µg/L	200 - 300	600	M-109	11/30/1983	220	MW-5	309	700
				M-2R	12/1/1983				
					3/6/1984				
Sr	µg/L	1000 - 2000	2600	M-108	1/6/2010	830	MW-1	1066	4000
							MW-4	869	
							MW-5	1080	
							MW-10	1002	

FIGURES


Modesto Junior College-West
Modesto Junior College-East
FMC Boundary
Former Disposal Ponds
Caltrans Soil Stockpiles
Modesto
Muni Golf Course
Tuolumne River
Orangeburg
Roseburg Ave.
Blue Gum Ave.
Woodland Ave.
Coldwell Ave.
Morris Ave.
Kansas Ave.
Needham St.
Elm Ave.
Maze Blvd.
California Ave.
Sierra Ave.
Tuolumne Blvd.
Rouse Ave.
Robertson Rd.
Paradise Ave.
Hatch Rd.
Hatch Ave.
River Rd.
Yosemite Blvd.
Scenic Dr.
La Loma Ave.
Carpenter Rd.
Carver Rd.
Rossmore Ave.
Grimes Ave.
Emerald Ave.
Tully Rd.
College Ave.
Sycamore Ave.
McHenry Ave.
Sunrise Ave.
M.L.K. Jr. Dr.
Jefferson St.
Sutter Ave.
Roselawn Ave.
Burney St.
Landing Rd.
Crows
9th St.
7th St.
2nd St.
L St.
J St.
H St.
D St.
99
108
132
0
1/2
Scale in Miles
N
EMKO Environmental, Inc.
551 Lakecrest Dr.
El Dorado Hills, CA 95762-3772
(916)939-0133
akopania@sbcglobal.net
Caltrans Modesto Soil Stockpiles
Stanislaus County, California
Vicinity Map
May 2014
Figure 1



FMC Site
WOODLAND AVE.
COLDWELL AVE.
CARPENTER RD.
HIGHWAY 99
NORTH 9TH ST.
TULLY RD.
COLLEGE AVE.
KANSAS AVE.
NEEDHAM ST.
EMERALD AVE.
MAZE BLVD.
L ST.
K ST.
M-105
M-9R
M-119
M-103
M-108
M-2R
M-104
M-106
M-102
M-151
M-153
M-6R
M-109
M-111
M-154
M-152
M-101
M-121
M-113
M-157
M-159
MW1
MW2
MW3
MW4
MW5
MW6
MW7
MW8
MW9
MW10
STOCKPILE 1
STOCKPILE 2
STOCKPILE 3
LEGEND:
M-159 Approximate FMC Monitoring Well Location
MW10 Approximate Caltrans Monitoring Well Location
0
800
Scale in Feet
EMKO Environmental, Inc.
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Caltrans Modesto Soil Stockpiles
Stanislaus County, California
FMC Site and Caltrans Modesto Stockpile Monitoring Well Locations
May 2014
Figure 2

EMKO Environmental, Inc.
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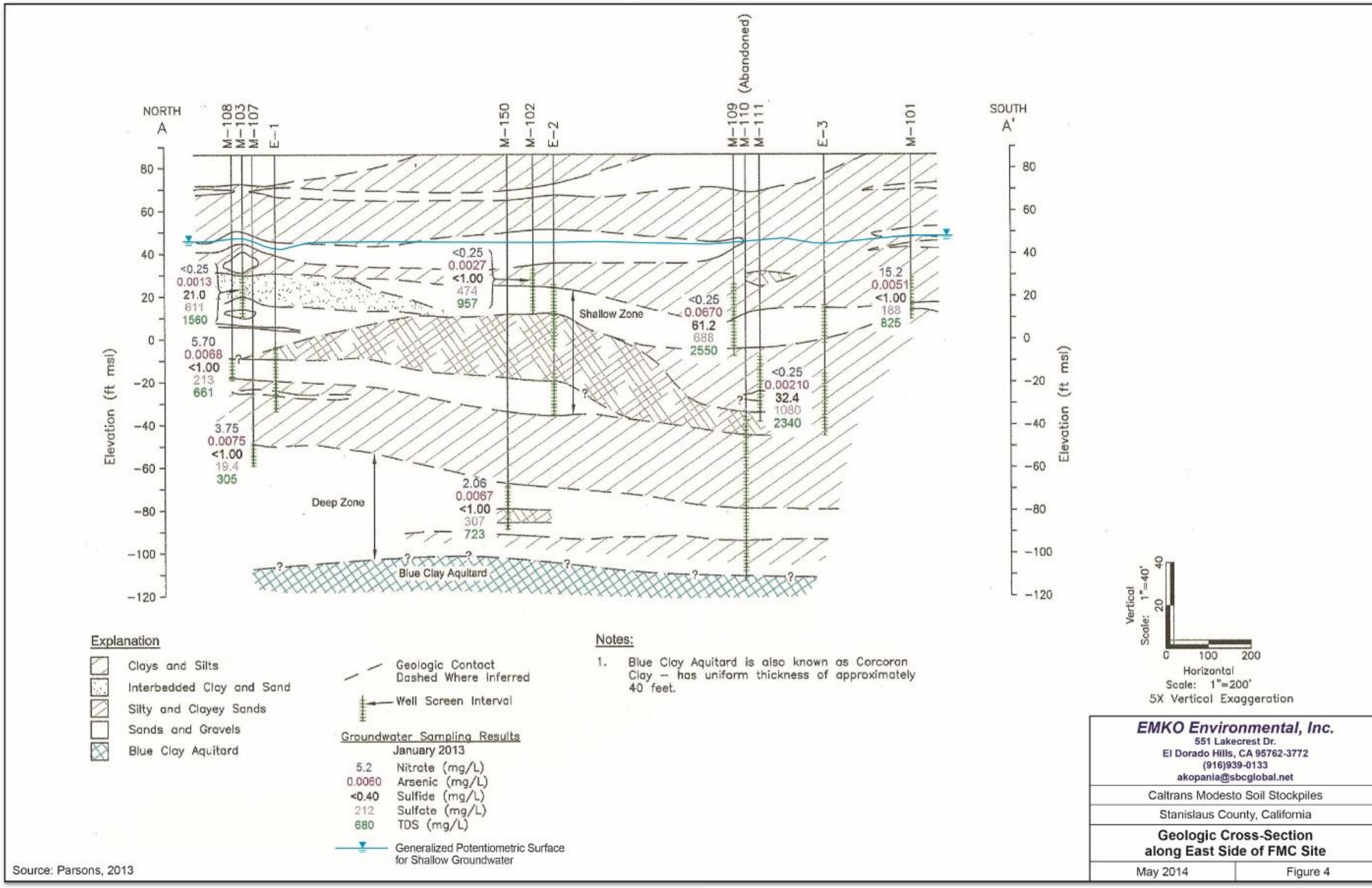
Caltrans Modesto Soil Stockpiles	
Stanislaus County, California	
Caltrans Soil Stockpiles and Monitoring Well Locations	
May 2014	Figure 3


NORTH
A
SOUTH
A'
M–108
M–103
M–107
E–1
M–150
M–102
E–2
M–109
M–110 (Abandoned)
M–111
E–3
M–101
Elevation (ft msl)
80
60
40
20
0
−20
−40
−60
−80
−100
−120
Shallow Zone
Deep Zone
Blue Clay Aquitard
<0.25
0.0013
21.0
611
1560
5.70
0.0068
<1.00
213
661
3.75
0.0075
<1.00
19.4
305
<0.25
0.0027
<1.00
474
957
2.06
0.0067
<1.00
307
723
<0.25
0.0670
61.2
688
2550
<0.25
0.00210
32.4
1080
2340
15.2
0.0051
<1.00
188
825
Explanation
Clays and Silts
Interbedded Clay and Sand
Silty and Clayey Sands
Sands and Gravels
Blue Clay Aquitard
Geologic Contact
Dashed Where Inferred
Well Screen Interval
Groundwater Sampling Results
January 2013
5.2 Nitrate (mg/L)
0.0060 Arsenic (mg/L)
<0.40 Sulfide (mg/L)
212 Sulfate (mg/L)
680 TDS (mg/L)
Generalized Potentiometric Surface for Shallow Groundwater
Notes:
1. Blue Clay Aquitard is also known as Corcoran Clay – has uniform thickness of approximately 40 feet.
Vertical Scale: 1"=40'
0
20
40
0 100 200
Horizontal Scale: 1"=200'
5X Vertical Exaggeration
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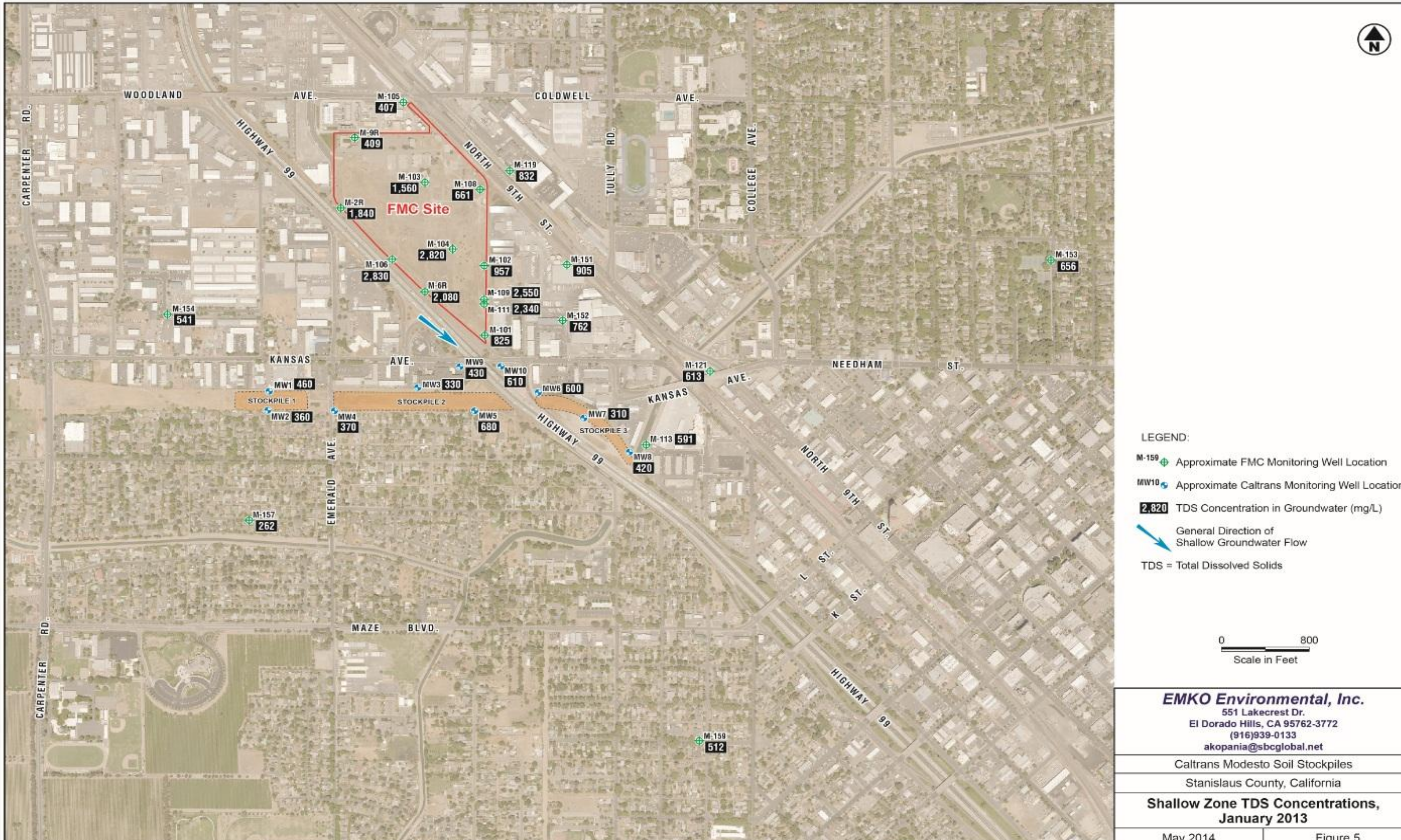
Stanislaus County, California
Geologic Cross-Section along East Side of FMC Site
May 2014
Figure 4
Source: Parsons, 2013


N
WOODLAND AVE.
COLDWELL AVE.
CARPENTER RD.
HIGHWAY 99
NORTH 9TH ST.
TULLY RD.
COLLEGE AVE.
KANSAS AVE.
NEEDHAM ST.
EMERALD AVE.
MAZE BLVD.
L ST.
K ST.
FMC Site
M-105 407
M-9R 409
M-103 1,560
M-108 661
M-119 832
M-2R 1,840
M-104 2,820
M-106 2,830
M-102 957
M-151 905
M-6R 2,080
M-109 2,550
M-111 2,340
M-152 762
M-101 825
M-154 541
M-153 656
M-121 613
MW9 430
MW10 610
MW1 460
MW3 330
MW6 600
STOCKPILE 1
STOCKPILE 2
MW2 360
MW4 370
MW5 680
MW7 310
STOCKPILE 3
M-113 591
MW8 420
M-157 262
M-159 512
LEGEND:
M-159 Approximate FMC Monitoring Well Location
MW10 Approximate Caltrans Monitoring Well Location
2,820 TDS Concentration in Groundwater (mg/L)
General Direction of Shallow Groundwater Flow
TDS = Total Dissolved Solids
0 800
Scale in Feet
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Stanislaus County, California
Shallow Zone TDS Concentrations, January 2013
May 2014
Figure 5

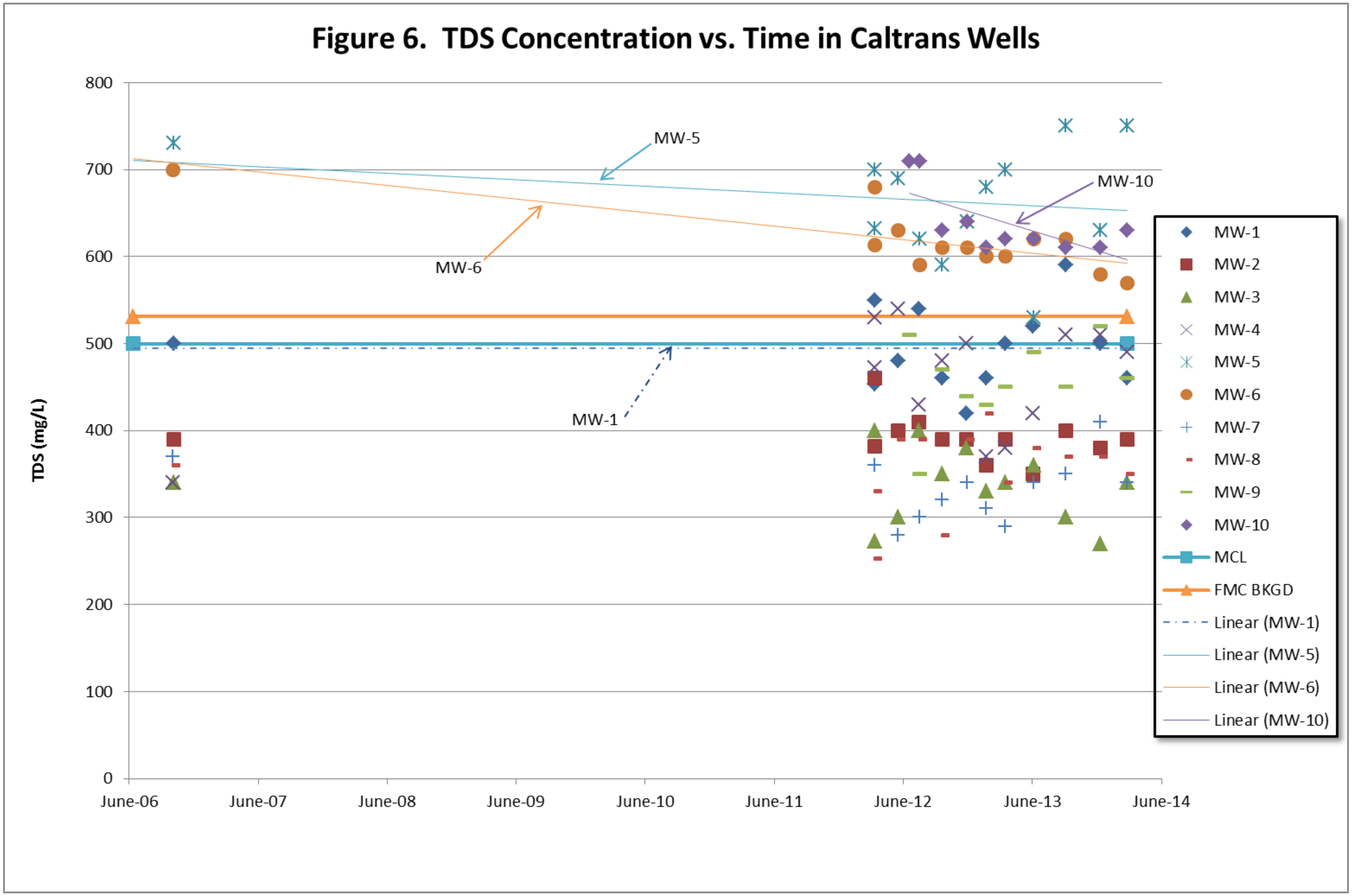
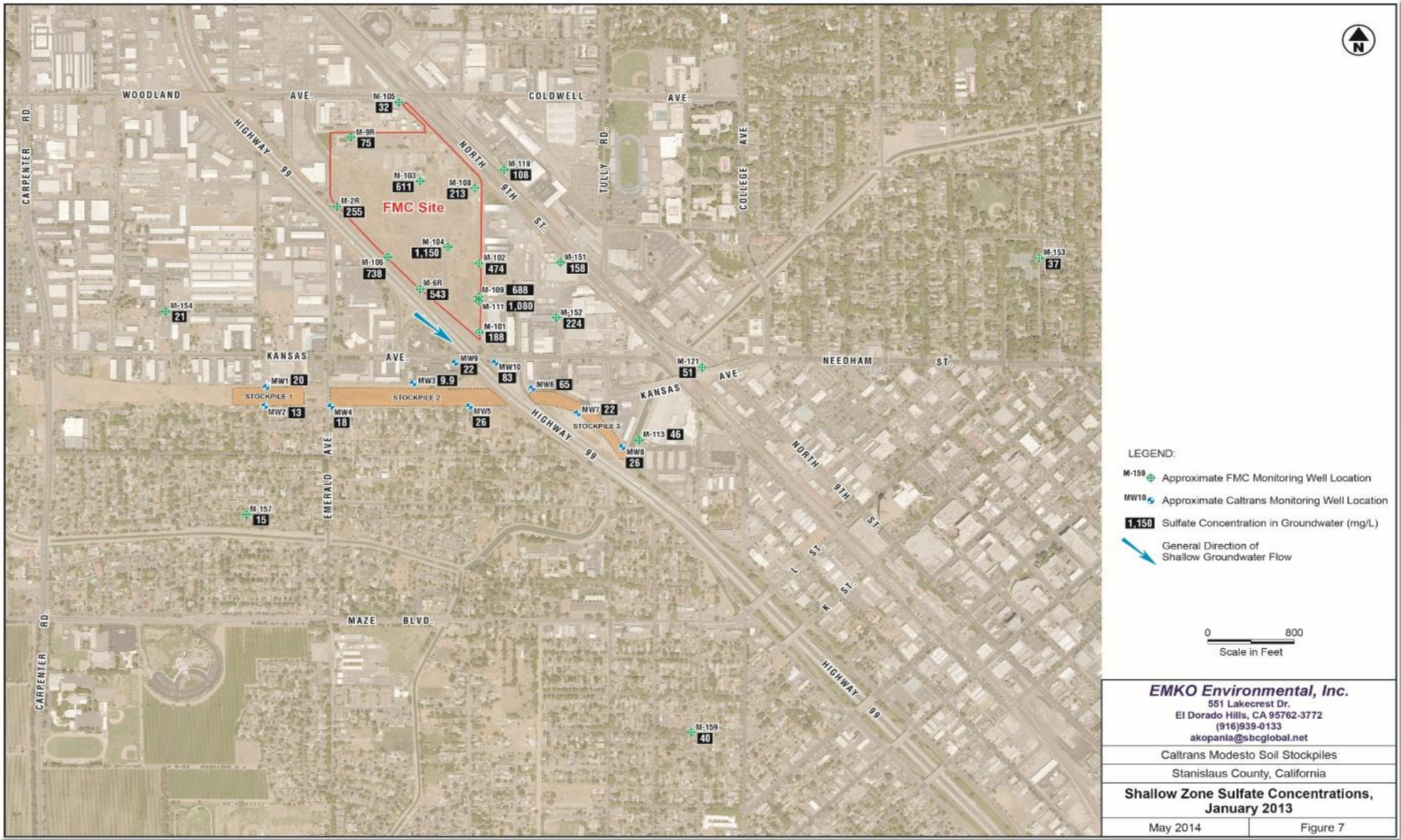


Figure 6. TDS Concentration vs. Time in Caltrans Wells
TDS (mg/L)
800
700
600
500
400
300
200
100
0
June-06
June-07
June-08
June-09
June-10
June-11
June-12
June-13
June-14
MW-5
MW-6
MW-10
MW-1
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MCL
FMC BKGD
Linear (MW-1)
Linear (MW-5)
Linear (MW-6)
Linear (MW-10)



WOODLAND AVE.
COLDWELL AVE.
CARPENTER RD.
HIGHWAY 99
NORTH 9TH ST.
TULLY RD.
COLLEGE AVE.
FMC Site
M-105 32
M-9R 75
M-119 108
M-103 611
M-108 213
M-2R 255
M-104 1,150
M-106 738
M-102 474
M-151 158
M-153 37
M-6R 543
M-109 688
M-111 1,080
M-152 224
M-154 21
M-101 188
KANSAS AVE.
NEEDHAM ST.
M-121 51
MW9 22
MW10 83
MW1 20
MW3 9.9
MW6 65
STOCKPILE 1
STOCKPILE 2
MW2 13
MW4 18
MW5 26
MW7 22
STOCKPILE 3
M-113 46
MW8 26
EMERALD AVE.
M-157 15
L ST.
K ST.
MAZE BLVD.
M-159 40
LEGEND:
M-159 Approximate FMC Monitoring Well Location
MW10 Approximate Caltrans Monitoring Well Location
1,150 Sulfate Concentration in Groundwater (mg/L)
General Direction of Shallow Groundwater Flow
0 800
Scale in Feet
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Caltrans Modesto Soil Stockpiles
Stanislaus County, California
Shallow Zone Sulfate Concentrations, January 2013
May 2014
Figure 7

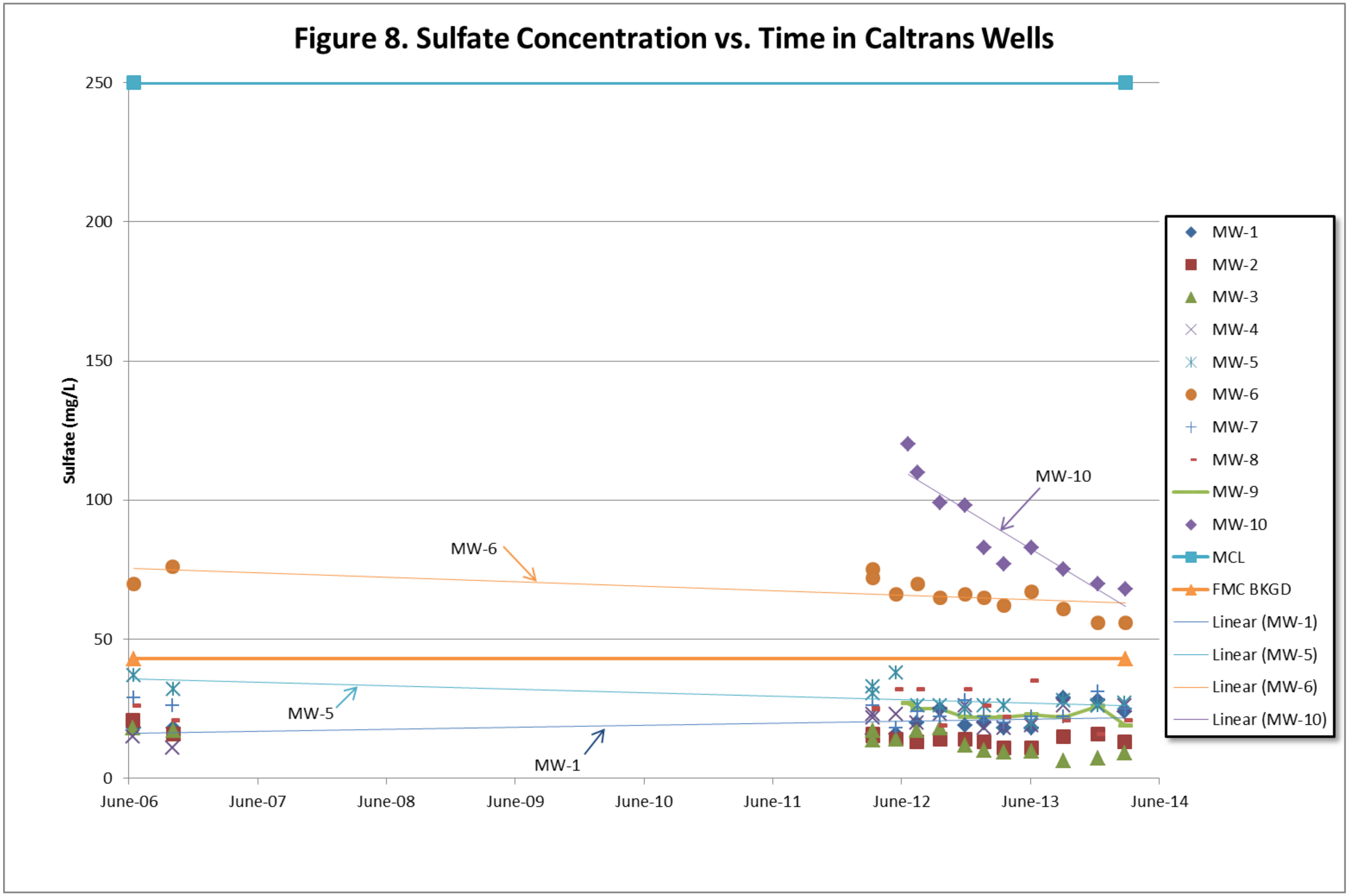
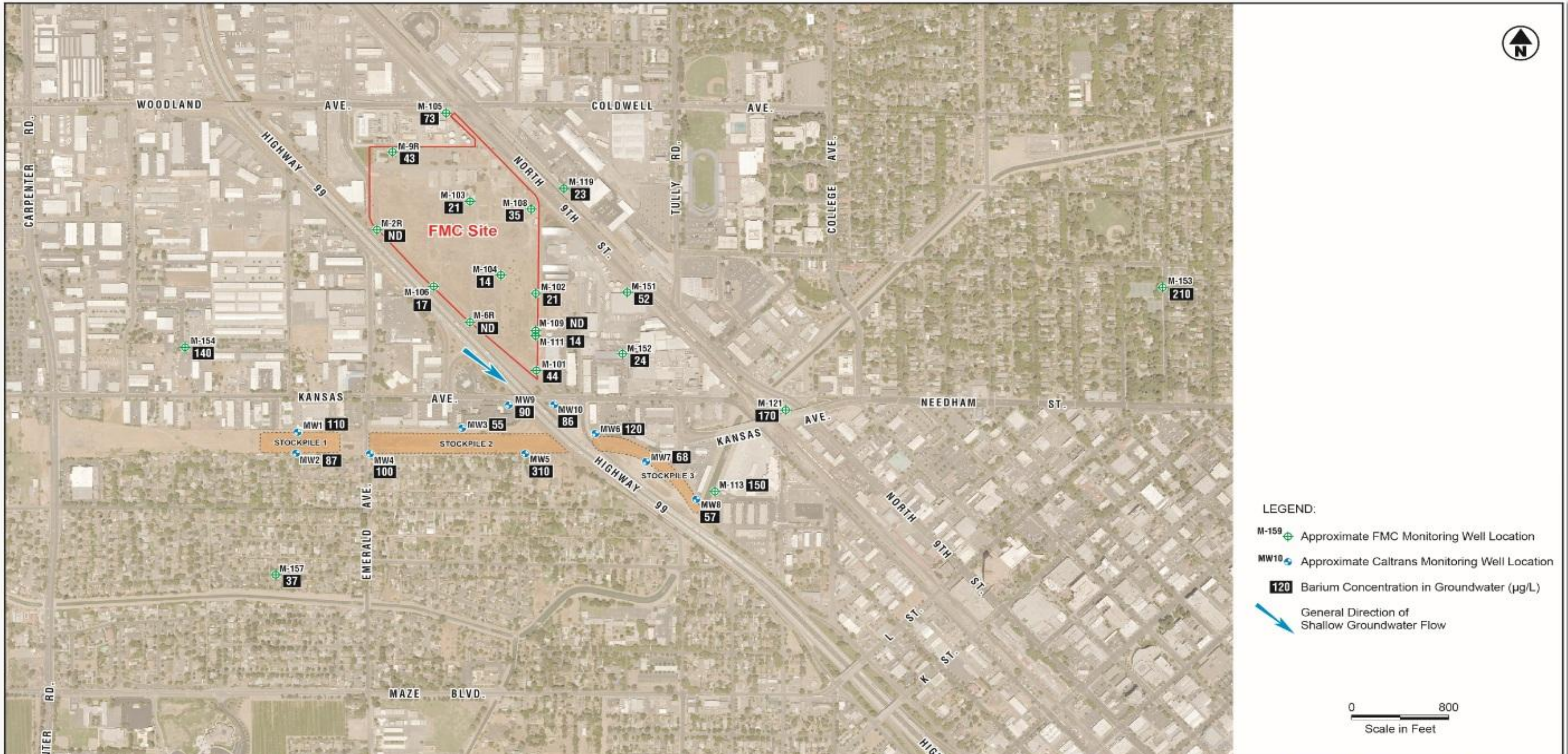


Figure 8. Sulfate Concentration vs. Time in Caltrans Wells
Sulfate (mg/L)
250
200
150
100
50
0
June-06
June-07
June-08
June-09
June-10
June-11
June-12
June-13
June-14
MW-10
MW-6
MW-5
MW-1
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MCL
FMC BKGD
Linear (MW-1)
Linear (MW-5)
Linear (MW-6)
Linear (MW-10)



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Caltrans Modesto Soil Stockpiles

Stanislaus County, California

Shallow Zone Barium Concentrations, January 2013

May 2014 | Figure 9

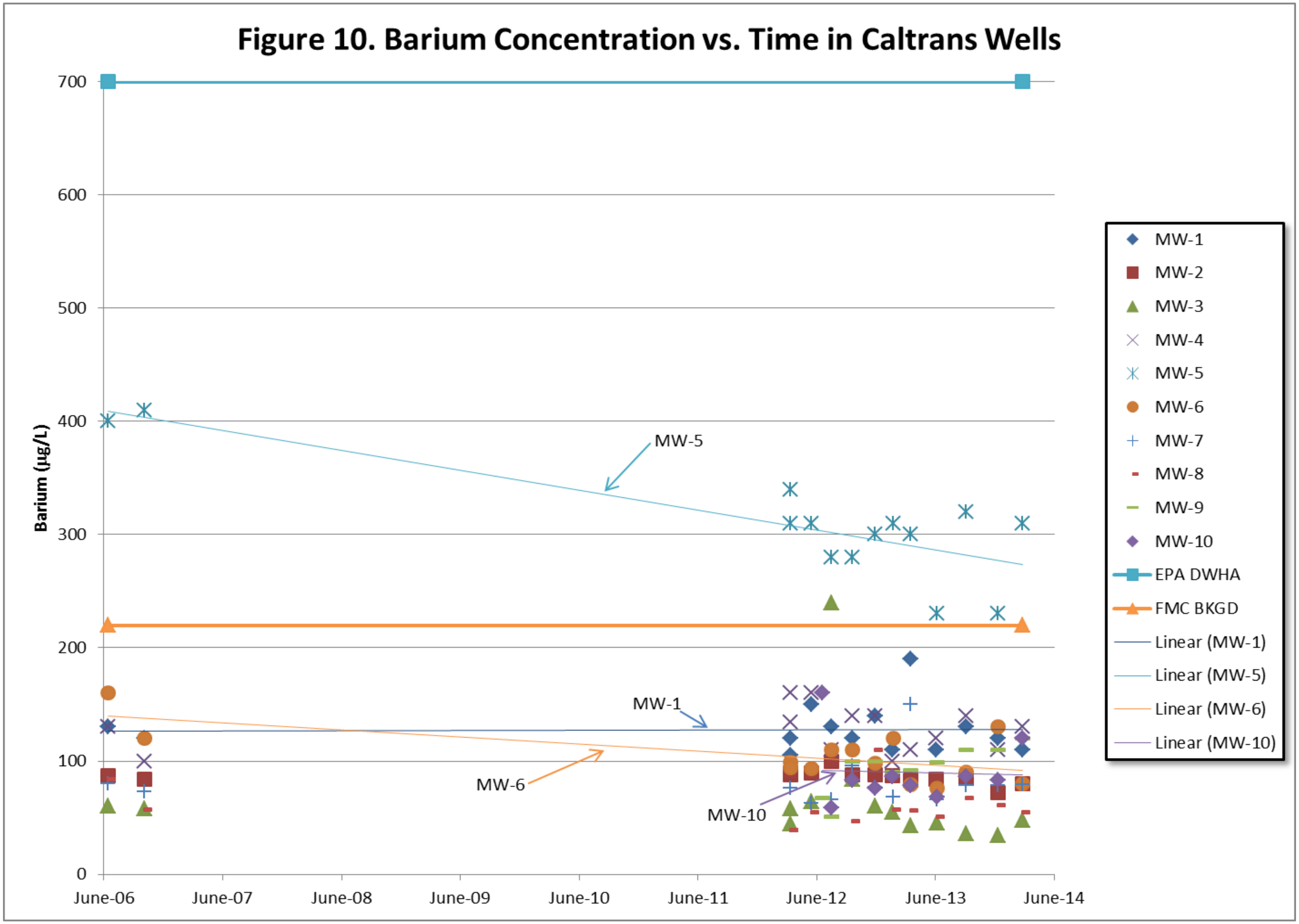
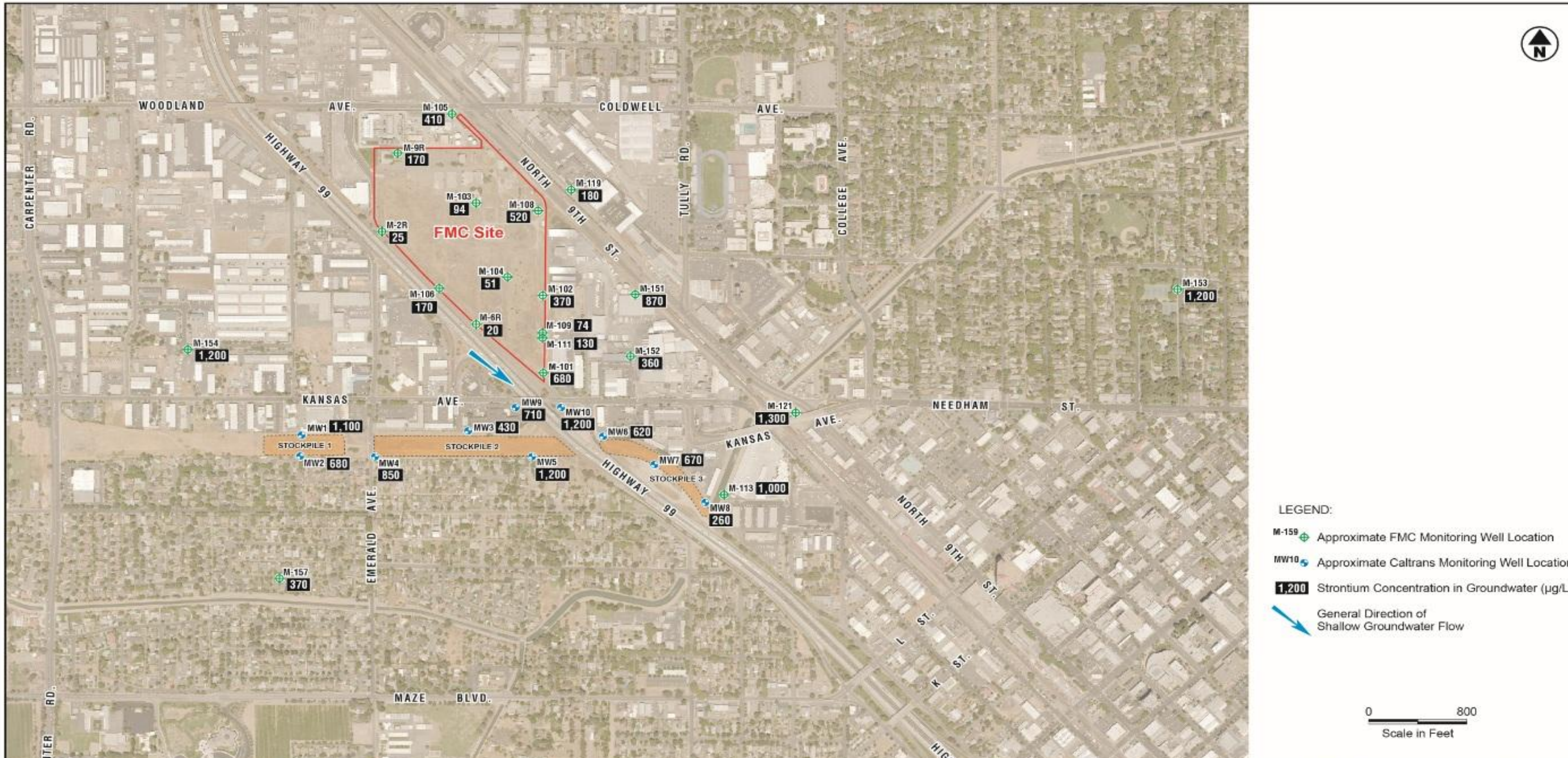


Figure 10. Barium Concentration vs. Time in Caltrans Wells
Barium (µg/L)
0
100
200
300
400
500
600
700
June-06
June-07
June-08
June-09
June-10
June-11
June-12
June-13
June-14
MW-5
MW-1
MW-6
MW-10
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
EPA DWHA
FMC BKGD
Linear (MW-1)
Linear (MW-5)
Linear (MW-6)
Linear (MW-10)



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Caltrans Modesto Soil Stockpiles

Stanislaus County, California

Shallow Zone Strontium Concentrations, January 2013

May 2014 | Figure 11

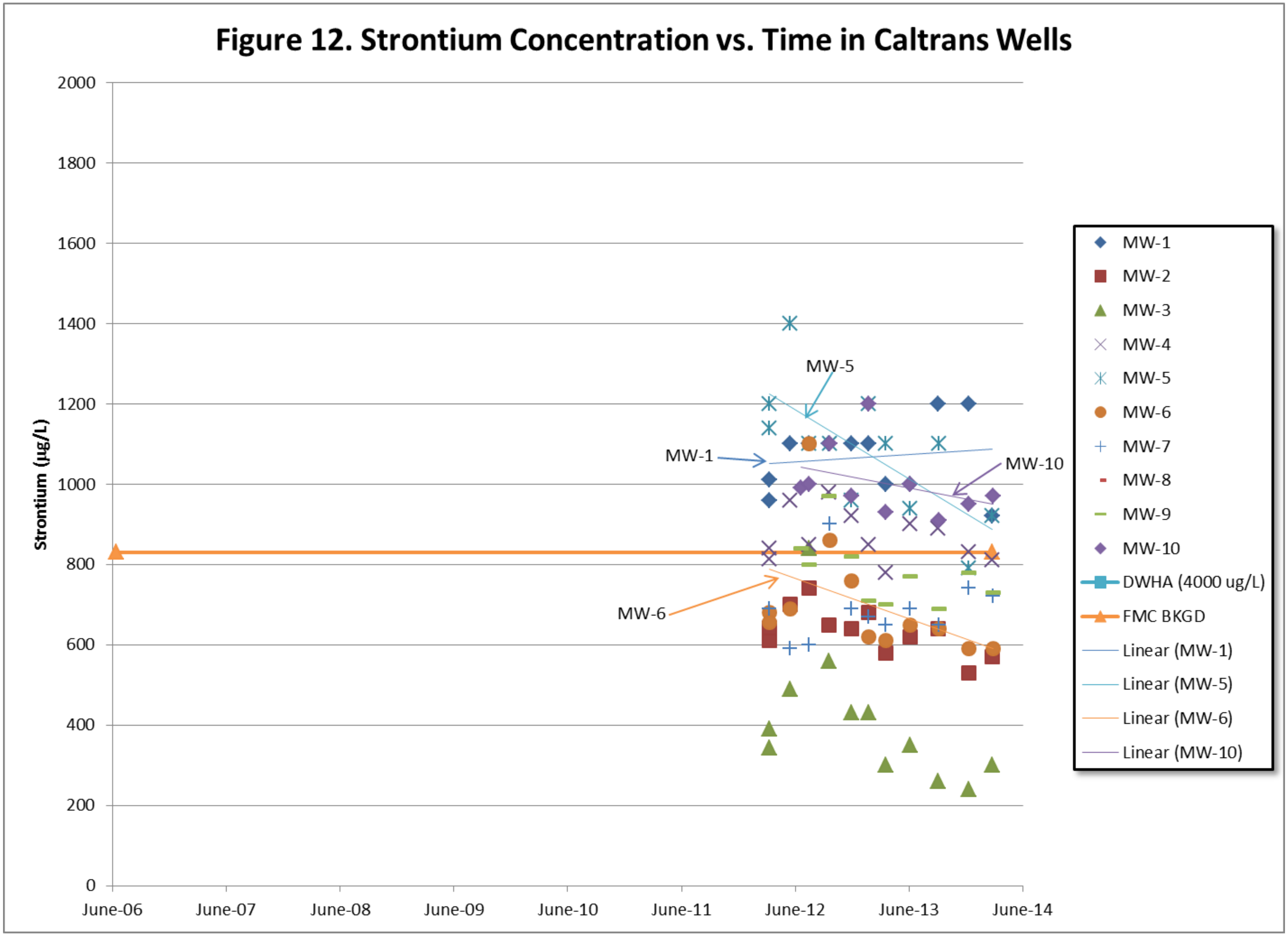

Figure 12. Strontium Concentration vs. Time in Caltrans Wells
Strontium (µg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
June-06
June-07
June-08
June-09
June-10
June-11
June-12
June-13
June-14
MW-5
MW-1
MW-10
MW-6
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
DWHA (4000 ug/L)
FMC BKGD
Linear (MW-1)
Linear (MW-5)
Linear (MW-6)
Linear (MW-10)